UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.
H. H. BENNETT, CHIEF

ADVANCE REPORT

on the

SEDIMENTATION SURVEY OF THE BENNETT IRRIGATION AND SILTING BASIN WILSONCREEK, WASHINGTON

August 17 - October 17, 1936

by

Jack L. Hough and Elliott M. Flaxman

Sedimentation Studies
Division of Research
SCS-SS-27
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In cooperation with

Washington Agricultural Experiment Station
Pullman, Washington
E. C. Johnson, Director

CONTENTS

ILLUSTRATIONS

INTRODUCTION

Ingenious methods of conserving the surface run-off from melting snows and utilizing its transported load of fertile silt for agricultural purposes have recently come to light in the semiarid sections of the Pacific Northwest. In certain parts of Washington the practice involves construction of earth-fill dams or dikes, with or without sluiceway outlets, across relatively flat-bottomed, steep-sided valleys to impound or cause the spreading of seasonal silt-laden flood flows. The practice results in (1) increasing the supply of moisture in the valley soils and subsoil gravels to such an extent that annual crops are made possible in a region where most of the agriculture is carried on by dry-farming methods, which require alternate seasons of fallow nonproductiveness for every field; and (2) building tillable soils on otherwise waste flats and annually renewing the soil fertility by inducing deposition of productive soil material. The simplicity of the practice, the success attained, and the apparent indirect benefits combine to make desirable further study of the possibility for more widespread development of this modification of irrigation farming and soil and water conservation in the Pacific Northwest and other sections of the country.

This report gives the results of a study of this practice mainly in the Bennett irrigation and silting basin, which lies in the semiarid region of east-central Washington, near the town of Wilsoncreek. The Bennett basin, a typical development of its type, is created by an earth-fill dam across the flat bottom of a steep-walled minor coulee, through which passes the intermittent flow of Wilson Creek. This basin not only provides for impounding spring run-off as an irrigation measure, and for deposition of new productive soil material, but also serves to minimize erosion by flood discharges on the included farm land and to lower flood peaks downstream by detention of water until peak run-off from the drainage area has subsided.

This investigation, which included a survey similar to a reservoir sedimentation survey insofar as its methods are applicable to a drained lake, was made during the period August 17 to October 17, 1936 by the Section of Sedimentation Studies, Division of Research, Soil Conservation Service. The survey party consisted of Elliott M. Flaxman, chief, Jack L. Hough, assistant chief, Leland H. Barnes, Alvin T. Talley, and Glen Petrick.

Comparative tests of the fertility of sediment deposited in the basin, original soil on the valley bottom, and soil in the drainage area were made by the Washington Agricultural Experiment Station at Pullman under an informal cooperative agreement with the Soil

Conservation Service. Volume-weight determinations on five samples of lake sediment were made by the Soil and Water Conservation Experiment Station at Pullman, Wash.

Photographs of the Bennett basin were taken by J. G. James, staff photographer of the Regional office of the Soil Conservation Service at Spokane, Wash.

The Soil Conservation Service is indebted to Mr. T. Claud Bennett, owner of the irrigation and silting basin and builder of Nile Valley Dam, for information regarding the history and development of the basin. The cooperation of Dr. L. C. Wheeting of the Washington Agricultural Experiment Station in collection of soil samples, and of Dr. Glen M. Horner, superintendent, Soil and Water Conservation Experiment Station, Pullman, Wash., in laboratory study of the fertility of the soil samples, is acknowledged.

THE COULEE DISTRICT

The region in which the Bennett basin lies is one of peculiar physical characteristics. Known as the Coulee district, it forms the northwestern part of the Columbia Plateau, a great lava plain lying just east of the Cascade Mountains. The entrenched Columbia River flows around the margin of the plateau in a great bend on the north, west, and southwest (fig. 1). Hills in the northern part of the district reach an elevation of 2,600 feet, and the plain descends to an elevation of less than 1,000 feet at its southwestern edge. The major slopes and drainage of the district are to the southwest, directly across the arc formed by the river.

Most of the underlying rock consists of nearly horizontal beds of basaltic lava. The general surface of the basalt is essentially the original surface of the lava flows, incised here and there by valleys that are cut deeper than the mantle rock. Overlying the basalt is a mantle of fine-grained loesslike material as much as 200 feet thick in some places.

This district is distinguished by a type of erosion topography that is not known elsewhere in the United States. It originated in the Pleistocene glacial period when ice dammed the Columbia River northwest of the Coulee district, and water discharging from melting glacial ice on the north was forced to sweep across the comparatively smooth surface of the plateau as a braided, weblike system of torrential streams. These streams followed the pre-existing shallow drainageways and stripped the mantle rock from broad belts, leaving the surface of the basalt exposed. The stripped

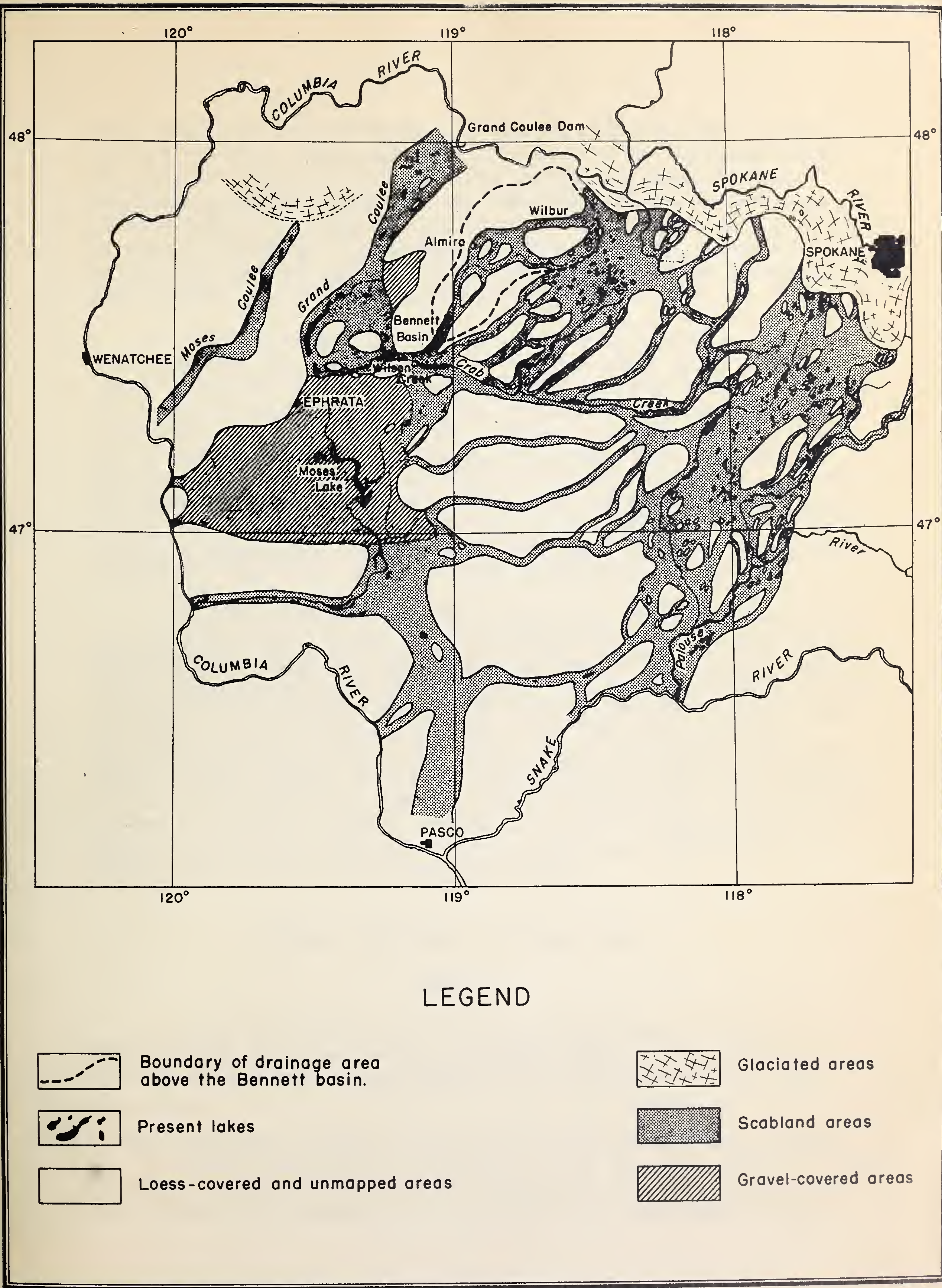

FIGURE I.–The Coulee district of the Columbia Plateau, east-central Washington, showing location of the Bennett basin and its drainage area.
After J H. Bretz

belts have been termed "Scablands" because of the peculiar appearance of the pitted basalt surface. In most of the scabland tracts the glacial waters cut channels into the basalt, many of them of considerable depth. These are the "coulees"--steep- to vertical-sided canyons with comparatively flat bottoms. In the waning stages of glacial discharge gravel deposits of considerable volume were left in many of the coulees. Unaltered remnants of the loess-covered plateau were left between the scabland tracts.[1]

Since the Coulee district is in the rain shadow of the Cascade Mountains precipitation is low over the whole area. At the lower elevations in the southwestern part less than 8 inches of rain falls in an average year, while the extreme northeastern part receives only 15 to 18 inches. The heaviest precipitation normally occurs during the winter and spring, the summer usually passing with no appreciable rainfall. Most of the drainage courses are dry for several months each year. In the drier parts of the area sagebrush, interspersed with bunchgrass, is the dominant form of vegetation. Before cultivation was begun the higher parts of the plateau supported a vegetative cover in which bunchgrass predominated.

The first inhabitants settled along the stream bottoms, where they harvested some native hay each fall and cultivated grain on a small acreage. By 1900, and perhaps earlier, wheat was being grown on the loessial soils of the plateau, and by 1910 dry-farming was at its peak on the upland. Since 1910 the trend has been toward fewer but more extensive holdings because of the low yield per acre. Practically all the wheat grown in the region is produced under the fallow system, whereby a field is sown to wheat in one year and kept in clean cultivation the next to conserve moisture for the following season. The census figures for 1929 indicate an average yield of about 12 bushels of wheat per acre for the area. Cattle are grazed on the poorer lands of the scabland tracts.

GENERAL CHARACTER OF DRAINAGE AREA

Extent

The watershed above Nile Valley Dam encloses an area of approximately 475 square miles, extending from the dam, which is about 3 miles north of the junction of the Wilson Creek and Crab

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[1]The geological history of the Coulee district is given in detail by J H. Bretz, The Channeled Scablands of the Columbia Plateau. Jour. Geology, Vol. 31: 617-649, 1923. See also subsequent papers by the same author in the Journal of Geology and the Geographical Review.

Creek Valleys, 70 miles northeastward to a point no more than 2 miles from the Columbia River. In the absence of topographic maps of the area it was necessary to plot the watershed boundary on maps showing drainage lines only; consequently the figure given for the watershed area is only approximate.

Geology and Topography

A belt of channeled scabland developed on the basalt constitutes the main axis of drainage above the Bennett basin. The northeastern part of the drainage area is dominantly scabland, incised by a system of anastomosing valleys that extend through the central part of the area and coalesce into a single strip a few miles above the Bennett basin. The principal channel in the lower scabland strip begins as a shallow cut in the vicinity of Wilbur, approximately 30 miles upstream from the basin, and increases in depth southwestward.

Loess-covered uplands, the largest single area of which is in the northwestern part of the drainage basin, occupy nearly 60 percent of the total drainage area. The northwest upland is thoroughly dissected by a dendritic system of shallow drainageways, whose development has been influenced by local base levels determined by the underlying basalt. The marginal slopes descending from the loess-covered uplands to the scablands commonly are very steep, amounting to as much as 35°. The scabland areas are in general gently sloping, but in detail the surface is very irregular. The sides of the Nile Valley coulee are steep in the vicinity of the Bennett basin, and in many places upstream they are vertical.

Elevations in the drainage area range from about 2,600 feet above sea level in the loess-covered hills on the north to about 1,375 feet in the channel near the dam.

Soils

The soils in the loess-covered areas are the Ritzville and Wheeler loams. These two types grade into each other and are related to the Palouse soils, which are of wide occurrence in the higher country to the east. The Ritzville and Wheeler soils include undifferentiated fine sandy loam, very fine sandy loam, and silt loam members. The surface soils of the Ritzville loams are predominantly dark brown, although the color becomes gradually lighter from east to west. They are developed from noncalcareous material, but free lime occurs at various depths below 30 inches. The subsoils are light grayish brown. The Wheeler loams are brownish gray,

the color being determined by oxidized iron minerals, together with a small amount of organic matter. The soil profile, in all respects other than color of the surface soil, is essentially like that of the Ritzville loams.

The principal soil of the coulee bottom is the Esquatzel loam, which has developed on the finer-grained deposits of the valley fill. The surface soil of the Esquatzel loam usually consists of a 12- to 15-inch layer of friable even-textured very fine sandy loam, ranging in color from light brown to brown. The upper subsoil layer consists of rather compact very fine sandy loam or, in places, loam that is light brown or light yellowish brown in color. This layer is underlain by stratified materials that are usually of somewhat finer texture. In places gravel is present below a depth of a few feet and extends to bedrock, and in a few small areas bedrock lies within a few feet of the surface. The subsoil of the Esquatzel loam is generally calcareous.

Borings within the reservoir basin have shown that several feet of old flood-plain deposits underlie the lake sediment. Immediately beneath the lake deposits over most of the basin is a layer of yellowish-buff medium-fine- to medium-grained silt averaging about 5 feet in thickness. This layer is underlain in many places by a bed of light-buff to cream-colored very fine sand which has an average thickness of about $2\frac{1}{2}$ feet. Below this bed are variable sediments in which the most common material is yellowish-buff medium-grained silt containing grains of basaltic sand, which in turn may be underlain by yellowish-buff to brown fine silt and clay, also containing basaltic sand.

Other soils in the drainage area, especially in the scabland areas, are poorly developed and are of little importance agriculturally.[2]

Land Use

The history of land use in the area tributary to the Bennett basin is typical of that of the Coulee district as a whole. The loessial soils cover about 270 square miles (55 to 60 percent of the total drainage area), practically all of which has been devoted to wheat cultivation by alternate crop and summer-fallow dry-farming methods. As in other parts of the district, low yields have forced

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[2]Strahorn, A. T., and others. Soil Survey (reconnaissance) of the Columbia Basin Area, Washington. U. S. Dept. Agr., Bur. Chem. and Soils, Ser. 1929, No. 28.

a reduction in the number of individual holdings and an increase in the acreage of each. Scabland areas, poor in soils and vegetation, have been used only for stock grazing. Certain sections of the coulee bottom in the lower 30 miles of the valley were settled before 1900.

Erosion Conditions

The thick mantle of unconsolidated loess, with its rolling topography and dominantly silty texture, is particularly susceptible to erosion when bare of vegetation. Erosion is caused by a combination of rains and water from melting snow in the colder months and by wind in the warmer part of the year. Development of a fine pattern of shallow shoestring gullies on the slopes and the inevitable sheet wash on areas between the gullies have resulted in the removal of large quantities of topsoil. Plowing the land each year destroys the finer branches of the gully systems and thus retards erosion to some extent, but this periodical removal of the more obvious marks of erosion tends to mask the serious nature of the process. Many of the cultivated slopes have lost between 25 and 50 percent of their topsoil in the relatively short period of cultivation.

THE BENNETT IRRIGATION AND SILTING BASIN

The Bennett basin (figs. 2 and 3, following p.20), owned and operated by Mr. T. Claud Bennett, is in Grant County, T. 23 N., R. 30 E., on Wilson Creek, about 3 miles northeast of the town of Wilsoncreek. Wilson Creek is an intermittent stream in Nile Valley, one of the many scabland channels of the Coulee district.

Nile Valley Dam, built of earth from the valley floor, has a maximum height of 30 feet, a maximum width at the base of 120 feet, and a top width of 12 feet. The slope of the downstream face is 1 1/2:1, and that of the upstream face is 2 1/2:1. The main dam (fig. 4) extends due west 925 feet from the east valley wall to a natural gravel hill on the valley floor. A low dike extending from this hill to the west valley wall completes the dam. The basin can be completely drained by means of an outlet in the base of the main dam, consisting of a concrete conduit with arched roof and vertical sides, 8 feet wide, 8 feet high, and 46 feet long, which leads to a concrete apron over which water passes to the valley below the dam (figs. 6 and 7). The calculated maximum discharge with a full reservoir is 1,500 cubic feet per second. A wooden gate, placed over the upper end of the outlet prior to the flood season each year, is raised by a windlass when it is desired

Figure 4.--Main section of Nile Valley Dam, the Bennett basin, near Wilsoncreek, Wash.

Figure 5.--Upper part of the Bennett basin, showing the level floor and winding stream channel.

Figure 6.--View of outlet in Nile Valley Dam, from the upstream end. Note the height of wheat growing in the basin, as shown by the stalks held by the man in the tunnel.

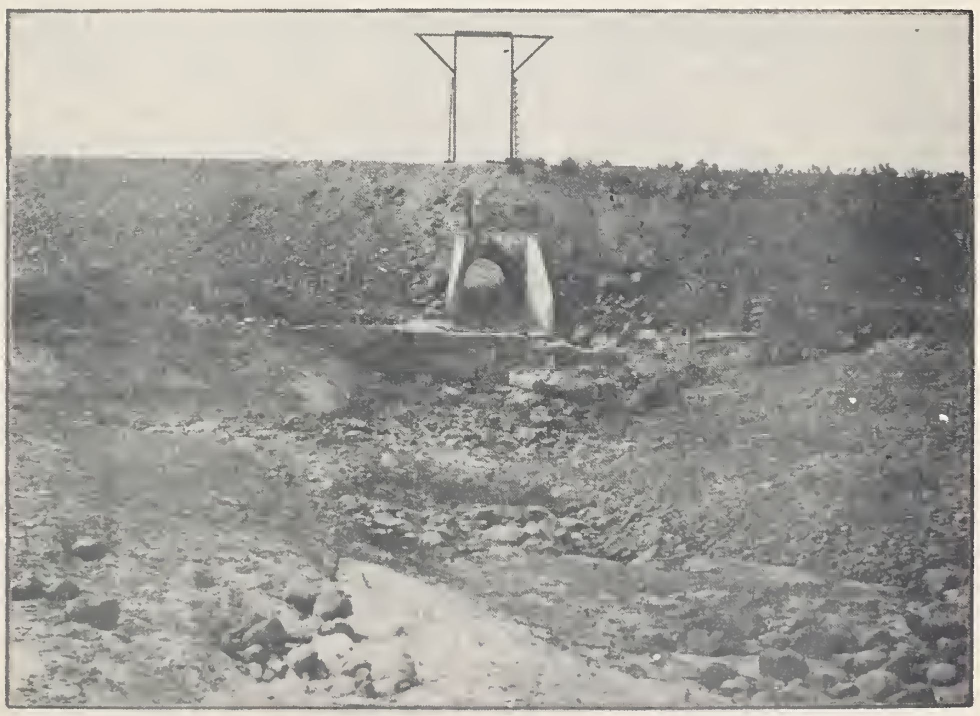

Figure 7.--View of outlet in Nile Valley Dam, from the lower side. The concrete apron has been undercut and partly destroyed by discharge waters.

to drain the basin. The gate is not opened completely unless a severe flood threatens the overflow spillway.

The original spillway was a boulder-paved channel on the east side of the gravel hill to which the dam is tied. This spillway was inadequate to discharge a flood in 1932, and a section of the dike west of the spillway was washed out. A new dike was constructed around the gap, and a temporary spillway, protected with sandbags, was built in this section. Discharge over the new spillway passes through the break in the original dike and into a shallow draw on the side of the gravel hill.

The reservoir basin occupies a section of the Nile Valley coulee that has comparatively straight, steep sides, unbroken by any important tributary valleys. This coulee has been filled with gravel to a depth of about 175 feet, and its present floor is about 200 feet below the valley rim. Before the dam was built low gravel hills near the dam site created a local base level that caused flood-plain deposition of silt, sand, and gravel and produced a gently sloping surface that rises gradually toward the present head of backwater. During the greater part of the year all water that enters the head of Nile Valley sinks into the gravel substratum before it reaches the Bennett basin. Wells driven to the bottom of the gravel yield water at all times. Deposition of sediment from the ponded water in the basin has tended to produce a surface of even greater smoothness than that of the underlying pre-lake flood-plain deposits. A channel (figs. 3 and 5) leading from the upper end of the basin to the outlet in the dam meanders back and forth on the basin floor and, during the wet season, carries the water of Wilson Creek when the basin is drained. The channel is 4 to 8 feet deep and about 30 feet wide at the top. Its sides are maintained at a low angle of slope by treatment during the spring plowing. Alfalfa is grown on the floor of the basin outside the channel, and wheat is seeded in the channel each year after the water has been drawn off.

A little less than a mile above the dam is a dike about 8 feet high extending from the east valley wall to a point within 200 feet of the west valley wall. This dike was constructed to flood the upper part of the basin in years when the run-off was not sufficient to fill the entire basin to crest level. Since the spillway has not yet been built, this auxiliary dam has never been used. The construction of this dike made it necessary to relocate a section of the creek channel to lead the drainage around the structure. A second dike at the head of the basin separates it from the John Seleen farm, the adjacent property upstream. A relocation of the channel was also made to lead the drainage around this dike.

Water was first impounded in the Bennett basin in the spring of 1918. As the average date of the sedimentation survey was September 1936, the age of the basin (in terms of spring flood seasons) at the date of survey was 19 years. The length of the basin, measured from the southernmost point of the dam to the closure of the crest contour, was originally 2.24 miles, and it had not been appreciably reduced by silting at the date of survey. The area of the lake at crest stage is 345 acres. The storage capacity to crest level was originally 2,903 acre-feet but had been reduced to 2,433 acre-feet at the time of survey by the accumulation of 470 acre-feet of sediment.

METHOD OF SURVEY

The original capacity and the volume of sediment in the Bennett basin were determined by both the range and contour methods of survey.[3] A horizontal control of 17 triangulation stations was expanded from a 1,100-foot base line located in the basin about 3,000 feet above the dam and extending approximately N. 60° W. From this control 44 ranges were established, of which 30 lie wholly or partly within the Bennett basin and the remaining 14 cross a series of 6 small basins on the John Seleen farm immediately above. Range cross sections and surface contours will serve as a basis for future determinations of sediment accumulation in the Bennett and Seleen basins.

Borings to the original basin floor were made with an Iwan auger at intervals along range lines and were located by plane-table intersection. Nile Valley Dam has little or no effect on the deposition of sediment in the Seleen basins, and the thin deposit in those basins did not warrant mapping the pre-lake surface in the 1936 survey.

An assumed elevation of 100 feet was assigned to the spillway crest, with reference to which the elevations on a series of 22 bench marks around the basin were established by a closed level traverse. Elevations of the silt surface and the original basin floor were determined at each boring location by secondary traverses and served as the major control in contouring the basin. Supplementary elevations were determined in the hilly section immediately above the dam, in the winding stream channel, and at points of considerable relief on the basin floor.

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[3] Eakin, H. M. Silting of Reservoirs. U. S. Dept. Agr. Tech. Bull. 524: 25-28, 128-136, 1936.

The elevation of the spillway crest, as determined by a level traverse from a U. S. C. & G. S. bench mark,[4] is 1,390.30 feet above mean sea level. A permanent bench mark was established by this survey at triangulation station 1006 and tied to both sea-level datum and the assumed datum at the spillway crest level. The elevation of the bench mark was determined to be 1,398.997, sea-level datum, and 108.697, assumed datum. Range ends were permanently marked with lengths of iron pipe that were stamped with the station numbers and either driven into solid ground, or, at insecure points, imbedded in concrete.

The field party, under the terms of a cooperative agreement with the Washington Agricultural Experiment Station at Pullman, Wash., assisted in the collection of five soil samples, three from the Bennett basin, one from the valley bottom below the dam, and one from a cultivated field in the drainage area. Five additional samples for porosity studies were obtained from three localities in the basin by driving sections of 3-inch galvanized sheet-iron gutter pipe into the sediment. Disks of sheet iron, soldered to the ends of the sections of pipe, made the containers airtight.

OPERATION OF THE BASIN

The primary purpose of the Bennett basin, which determines its method of operation, is to supply moisture to the cropland within its limits. The other benefits derived from its operation are considered by the owner to be incidental.

Water Conservation

Aside from the normal precipitation the only water supply of practical importance to crop production in the vicinity of the Bennett basin is that which is available for a short period in the spring when melting snow in the catchment area produces a surface flow in the lower reaches of Wilson Creek Valley. Water is impounded in the basin for a sufficient period to thoroughly saturate the soil, usually about two weeks. Frost must be out of the ground before water is impounded, or infiltration will be poor.

After the period of storage, the outlet in the base of the dam is opened and the water drained off. As soon as the surface soil is

[4]B. M. No. M-69-1934 (el. 1,276.087) near the Great Northern Railway water tower in Wilsoncreek.

sufficiently dry to permit tillage, the alfalfa land is harrowed or disked to break up the new layer of sediment that has accumulated. The channel banks, where they have been undercut during inflow or drainage of the basin, are worked to restore their gentle slopes, and the channel areas are plowed and planted in wheat. In ordinary years sufficient moisture is stored in the ground to produce two or three cuttings of alfalfa during the growing season.

The amount of water reaching the basin in the spring depends not only on the amount of snow in the catchment area but also on the rate of melting and the condition of the ground. If melting is slow and the ground is not frozen, a large amount of the melt-water soaks into the porous silty soil on the uplands and into the gravel substratum in the valley, and little or no water flows at the surface in the lower reaches of the valley. In ordinary years the first flow in the lower valley occurs in February. There may be one flood or several small flows, each of which may come on rapidly or slowly. In 2 out of the 19 years of operation prior to the survey of 1936 no water reached the basin, and in 2 or 3 other years only about 40 acres were flooded. In the spring of 1937 (after the sedimentation survey) there was abundant snow in the catchment area, but melting took place so slowly that all the water was lost in the substratum upstream from the Bennett basin.

Sediment Accumulation

Character of sediment.

In the time that water is impounded practically all the sediment reaching the Bennett basin settles from suspension. The surface sediment over the greater part of the basin is fine grayish-buff silt. The deposit increases in coarseness toward the head of the basin; in the area adjacent to the stream channel at the head it consists of coarse silt and sand.

The new deposits in the stream channel within the basin range from coarse silt to coarse sand, but the dominant type is medium-grained sand. The finer sand and sandy silt deposits, including minor amounts of basaltic sand, are yellowish buff in color, and the coarser sands, consisting largely of basalt grains, are dark gray.

Volume-weight relations.--The results of volume-weight determinations on five samples of sediment, collected in the undisturbed condition from three localities in the Bennett basin, are given in table 1.

Table 1.--Volume-weight relations of sediment samples from Bennett basin, near Wilsoncreek, Wash.

Sample no.	Description and location (All cores are 3 inches in diameter)	Dry wt. per cu. ft.	Porosity[1]
		Pounds	Percent
1.....	19-inch core from uppermost sediment layers on range R11-R12, 549 ft. from R12.	[2] 65.5	[2] 59.6
2.....	11-inch core from uppermost sediment layers on range R19-R20, 650 ft. from R20.	[3] 65.2	[3] 59.8
3.....	9-inch core from sediment layers between depths of 12 and 24 inches, at same point as sample 2.....................	[3] 68.0	[3] 58.1
4.....	11-inch core from uppermost sediment layers on range R47-R48, 350 ft. from R48.	[4] 69.8	[4] 57.0
5.....	9-inch core from sediment layers between depths of 12 and 24 inches, at same point as sample 4.....................	[5] 68.7	[5] 57.7
Average.......................................		67.4	58.4

[1] Porosity was determined from the dry weight of the sediment by assuming an average specific gravity of 2.6.
[2] Average of determinations on four sections of the core.
[3] Average of determinations on two sections of the core.
[4] Determined for middle section of core.
[5] Determined for entire sample.

In general, the porosity is slightly higher in the finer sediment in the lower part of the basin.

Distribution of sediment.

The sediment deposits in the basin range from a thin film to a bed 4 feet thick, the average thickness for the entire basin being about 1.4 feet, and for the cropland, 1.8 feet. Practically no sediment has been deposited on the steep sides of the basin outside the cultivated areas. In the section of the basin below the middle dike

(0.9 mile above the dam) the sediment is thickest in the central part and thins in all directions. In the upper section of the basin the sediment is thickest adjacent to the middle dike and thins gradually toward the head of the lake, except that on the east side of the basin near its head a relatively thick body of sediment has been deposited in a low area of the basin floor.

The average annual deposit in areas of maximum deposition has been about 0.2 foot. Since little or no sediment was added in some years, individual annual accumulations may have been as much as 0.4 foot in the years of greater deposition. This thickness is sufficient to be of potential danger in preventing the alfalfa from coming up in the spring. In years when the deposit of sediment is thin a harrow is used to break up the surface layer, but when the deposit is thick a disk is used. If the alfalfa is slow in coming up the land may be disked as many as three times. In certain years of heavy silt deposition the alfalfa was killed in some areas, but as frosts occurred in those years after the start of the growing season the killing may have been due to either factor or both.

Origin of sediment.

The principal source of the sediment deposited in the Bennett basin is the highly erodible loess cover of the uplands which extends over more than half of the drainage area. The chief erosional product of both the loess and basalt areas is silt. Sand is available in appreciable quantity only as a weathering product of the basalt.

Erosion Control

The stream channel in the old flood-plain deposits outside the Bennett basin is rectangular in cross section, but within the basin area the banks have been modified artificially to a low angle of slope to permit cultivation and crossing with farm equipment at any point. Flooding of the basin reduces current velocities so that in ordinary years very little erosion occurs, and the stream is prevented from migrating laterally and destroying the flood-plain and lake deposits. Floods that reach the basin when no water is impounded cut into the foot of the banks and necessitate plowing or more laborious measures to restore the desired slope.

Flood Control

In the season of spring snow-melting, run-off from the drainage areas of Wilson Creek and streams to the east produce floods in Crab

Creek Valley that cause extreme inconvenience and, in some years, damage to the town of Wilsoncreek. Storage of water in the Bennett basin during the flood season reduces the peaks of floods in Nile Valley and has some small effect in alleviating flood conditions downstream. The basin is not operated with this end in view, but such control is a natural consequence of its normal operation.

FERTILITY OF THE SEDIMENT

A study was made of the comparative fertility of the sediment deposited in the Bennett basin and other soils in the vicinity. For this purpose the following five samples were collected:

1. Soil from a typical wheatfield in the drainage area above the basin.

2. Sediment from the upper end of the basin, consisting of newly deposited relatively coarse material.

3. Old sediment, taken a short distance above the dam from a depth of 8 to 12 inches below the surface, which represents material that has been farmed for several years and subsequently covered with newer sediment.

4. Sediment deposited in 1936 along the edge of the basin a short distance above the dam, and not tilled prior to the time of its collection.

5. Ephrata very fine sandy loam from the valley floor below the dam.

The samples were analyzed at the Washington Agricultural Experiment Station to determine their mechanical and chemical composition and were subjected to pot-culture tests to determine their productivity.

The data given in table 2 show the mechanical composition of the five samples, as determined by the Bouyoucos method.

Table 2.--Mechanical composition of soils from Bennett basin and vicinity, near Wilsoncreek, Wash.

Sample	Mechanical composition		
	Sand	Silt	Clay
	Percent	Percent	Percent
1. Soil from drainage area..................	31.2	54.2	14.6
2. New sediment from upper end of basin....	44.0	43.8	12.2
3. Old sediment in basin...................	13.6	49.4	37.0
4. New sediment from lower end of basin....	10.4	40.2	49.4
5. Soil from valley bottom below dam.......	38.0	46.2	15.8

The texture of the samples varies widely, from the coarse sandy material deposited near the point where the stream enters the upper end of the basin to the very fine sediment deposited near the dam.

The results of chemical analyses of the samples are presented in table 3. The various samples showed no marked difference in reaction, the pH value of each indicating a slight alkalinity. The quantities of soluble phosphorous, potassium, and calcium were determined by the Spurway method.[5] No great difference was noted between the various soils in the content of these plant nutrients. The soluble salt content was highest in the newer sediment, although the amount was not excessive in any of the samples.

A wide variation was noted in the total nitrogen and organic carbon contents of the samples. The fine-textured sediments contained two to three times as much nitrogen and carbon as the other samples. The soil from the valley bottom below the dam had the smallest percentages of these two elements.

The nitrate-producing power was determined by incubating the soils under optimum moisture and temperature conditions, and then analyzing for nitrate nitrogen. The productivity of a soil is

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[5] Spurway, C. H. Soil Testing: A Practical System of Soil Diagnosis. Mich. State Agr. Exper. Sta. Tech. Bull. 132 (Revised), 23 pp., 1935.

Table 3.--Chemical characteristics of soils from Bennett basin and vicinity, near Wilsoncreek, Wash.

Sample	Reaction	Soluble salts				Total nitrogen	Organic carbon	Nitrate nitrogen		
		Phosphorous	Potassium	Calcium	Total			Initial	10 days	30 days
	pH	P.p.m.	P.p.m.	P.p.m.	P.p.m.	Percent	Percent	P.p.m.	P.p.m.	P.p.m.
1. Soil from drainage area.............	7.3	2.5	10.0	60.0	130	0.074	0.880	0	30	66
2. New sediment from upper end of basin.	7.2	2.0	10.0	60.0	335	.077	.946	19	70	80
3. Old sediment in basin.............	7.4	1.0	10.0	60.0	210	.187	2.293	6	40	90
4. New sediment from lower end of basin.	7.1	1.0	10.0	60.0	735	.218	2.440	75	100	170
5. Soil from valley bottom below dam...	7.3	2.5	10.0	60.0	105	.059	.640	0	20	50

closely related to its ability to furnish plants with a continuous supply of available nitrogen as well as other essential plant nutrients. Soils that have a high content of easily decomposable organic matter and a narrow carbon-nitrogen ratio are usually the most productive. The data given in table 3 show that the new sediment is superior to the other samples in this regard. The soils from the drainage area and from the valley bottom below the dam are the most deficient in available nitrogen.

The productivity of the five samples was tested by means of pot cultures. Three 3-gallon pots were filled with each soil and two crops were grown in succession. The pots were first planted to barley, and 12 plants were allowed to grow in each pot for three months. At the end of this period the dry weights of the tops and roots of the plants were determined and the soil prepared for seeding to alfalfa. No effort was made to thin the alfalfa to a definite number of plants per pot, but a good stand was obtained in all the pots. After four months' growth the alfalfa plants were removed from the pots and the dry weights of the tops and roots determined. The average weights for the triplicate pots are given in table 4.

Table 4.--Plant growth in soils from Bennett basin and vicinity, near Wilsoncreek, Wash.

Sample	Weight of plants (dry)			
	Barley		Alfalfa	
	Tops	Roots	Tops	Roots
	Grams	Grams	Grams	Grams
1. Soil from drainage area............	4.9	2.1	19.1	17.1
2. New sediment from upper end of basin............................	14.8	10.4	18.1	19.9
3. Old sediment in basin..............	7.2	5.7	17.7	19.3
4. New sediment from lower end of basin............................	40.8	6.8	32.5	24.2
5. Soil from valley bottom below dam..	4.2	2.6	12.0	12.9

There is a close relation between the organic-matter content and nitrate-producing power of these soils and their productivity. The most productive soils were those that were able to produce the largest amount of available nitrogen. The approximate order of the

five samples in relative productivity is as follows: (1) New fine-grained sediment from lower end of basin, (2) new coarse sediment from upper end of basin, (3) old sediment from basin, (4) soil from drainage area, (5) soil from valley bottom below dam. The barley and alfalfa crops grown on the five soils are shown in figures 8 and 9, respectively.

The original flood-plain material under the lake sediment of the Bennett basin was probably similar in mechanical and chemical composition to the sample of soil from the valley bottom below the dam. Assuming this to be true, the results of the fertility studies indicate that the deposition of new fertile sediment from year to year has not only counteracted the effect of repeated harvesting of crops without the application of fertilizers, but has actually increased the productivity of the basin fields.

BASINS AND DIKED FIELDS ABOVE THE BENNETT BASIN

The first dikes for impounding water in Nile Valley were constructed about 1908 on the John Seleen farm, immediately upstream from the Bennett basin. At the present time about 150 acres of alfalfa land on the John Seleen farm is irrigated by diversion of Wilson Creek, during flood season, into fields that are enclosed by low dikes averaging about 5 feet in height. Water is diverted from the creek by a small channel dam, consisting of a concrete base and piers with slots for the placement of timbers. From the dam the raised water passes through a gap in the dike enclosing the field farthest upstream and flows by gravity down the flood-plain slope into each field in turn through gates in successive dikes. After the lowest field has been flooded the flow of water is stopped by opening gates in the diversion dam and closing the gates in the dikes. Since only the top water is taken from the creek, the main flow of the stream does not cross the fields but is bypassed in the creek channel. Exploratory borings with a soil auger in the flooded fields showed that comparatively little sediment is removed from Wilson Creek by this method of diversion.

On the Lee Seleen farm, about 6 miles upstream from the Bennett basin, a part of the coulee bottom is irrigated by diversion of the spring run-off into diked fields, and part is watered by means of low dikes that cause water to spread over the valley floor during run-off periods but do not prevent it from draining away as soon as the flood subsides. The first dikes were built on this farm about 1916. As much as 3 inches of sediment is deposited during some spring floods, according to the owner. The land so flooded, totaling about 125 acres in area, is planted to alfalfa and oats. The yield per acre is said to be much greater than on fields outside the flooded area.

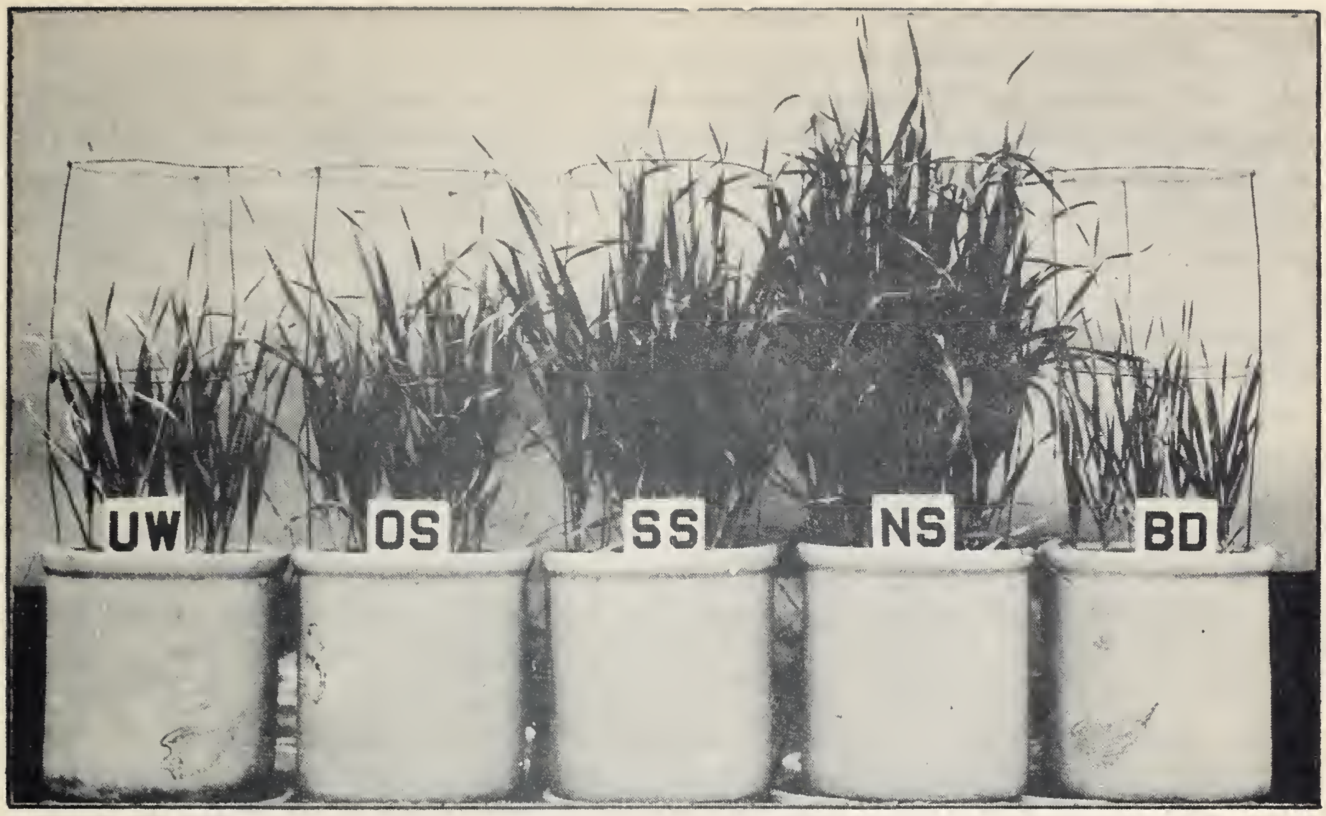

Figure 8.--Three-month growth of barley on five soil samples collected in and near the Bennett basin. Legend: (UW) Soil from drainage area above basin, (OS) Old sediment in basin, (SS) New sandy sediment from upper end of basin, (NS) New fine sediment from lower end of basin, (BD) Soil from valley bottom below dam.

Figure 9.--Four-month growth of alfalfa on five soil samples collected in and near the Bennett basin. Legend same as above.

There are three dams on the Lindblad Brothers farm, about 7 miles upstream from the Bennett basin. The lower dam, which is under construction, is an earth-fill structure 8 to 14 feet high that extends nearly the full width of the coulee bottom. Since the beginning of construction in 1931 the dam has served to spread the stream farther over the valley flat during floods. When the spillway is completed this dam will flood about 50 acres. The middle dam, an earth-fill structure about 12 feet high and several hundred feet long, extends completely across the coulee bottom. It was built in 1922 or 1923 and impounds water on about 90 acres. The upper dam, also an earth-fill structure extending the full width of the coulee bottom, was originally built in 1922 or 1923 to a height of 12 feet but was raised to 16 feet a few years later, after which it flooded about 60 acres. A part of the spillway was washed out in the spring of 1936. Alfalfa is the principal crop grown on all the fields of the Lindblad basins. In addition to the areas flooded by the dams a part of this farm, planted in potatoes, is irrigated by diversion of the small amount of water that flows in Wilson Creek in this part of the valley during the growing season.

On the main branch of Wilson Creek, a short distance above its junction with a small tributary that flows through Almira (or about 14 miles upstream from the Bennett basin), an earth-fill dam 8 to 10 feet high was built several years prior to 1936 and has been used to store water for irrigation of fields below. A considerable amount of fine-grained sediment has accumulated behind this dam. A section of the dam was washed out in 1934, and the basin has not been filled since then. The land within the basin is now grazed by cattle, and the farm lands below are irrigated by diversion of water from the Almira branch of Wilson Creek. This branch continues to flow during the summer, and as soon as the spring floods have subsided a small earth-fill diversion dam is thrown up to turn a part of the water into the irrigation ditches. These irrigated fields have never been flooded by impounded water, and the soil is rocky and poor.

Four miles farther upstream, on another branch of Wilson Creek, an earth-fill dam about 4 feet high impounds water on about 40 acres during the spring flood season. The soil of this field is a silty sediment similar to that of the Bennett basin.

IRRIGATION WORKS AND SILTING BASINS IN ADJACENT DRAINAGE AREAS

On the farm of W. E. Southard on Sagebrush Flat Creek, 14 miles northwest of Ephrata, Wash. (fig. 1), is an irrigation and silting basin similar to the Bennett basin. Dams 10 to 18 feet high impound water during the flood season on about 160 acres. Before construction of the

dams in 1926 the land was rocky and sagebrush was the principal vegetation. In the 10 years of operation preceding this investigation 3 to 12 inches of sediment was deposited in this basin, and alfalfa was grown successfully.

Other silting basins are in operation in the valley of Connawai Creek, east of the Wilson Creek drainage area, according to information supplied by Edwin O. Lindblad. These were not visited by the writers.

Several fields in Crab Creek Valley east of Wilsoncreek are irrigated by damming Crab Creek, which flows throughout the growing season. Small dams in the stream channel raise the water table in the flood plain and thus supply moisture for crop production. During the flood season the fields may be flooded, but no water is held after the floods subside.

SUMMARY

Scanty rainfall in the Coulee district of east-central Washington places water at a premium. The good soils of the loess-covered uplands must be worked by dry-farming methods, which generally permit the production of crops in alternate years only, and the low yield per acre makes large holdings of land necessary. Water is available in abundance in the coulee bottoms during the short period in the spring when snow is melting, but in many sections of the coulee bottoms no water flows during most of the growing season. The soils of the coulee bottoms in general are poor.

Various methods are used in the coulee bottoms to conserve the water of the spring floods and make it available to crops during the summer. Sufficient moisture for crop needs throughout the growing season usually may be provided by saturating the land by flooding in the spring. This is accomplished either by diverting a part of the stream flow into diked fields or by impounding the entire flow behind dams. In the diked areas moisture conservation is the only real benefit derived from flooding, but where the entire flow is impounded most of the sediment load of the stream is deposited on the farm land. The sediment is mainly fine silt derived from the soils of the plateau wheat farms. If the sediment is added to stony land, the soil texture is improved and the productivity is apparently increased.

A detailed study of the Bennett basin showed that an average depth of about 1.8 feet of sediment had been deposited on the cropland areas in a 19-year period. Fertility studies of the sediment and of soils in the vicinity indicate that the basin sediment is more fertile than the old valley soil. In ordinary years, when the moisture supply

is adequate, as many as three crops of alfalfa and a good yield of wheat are produced. Alfalfa is particularly adapted to this system of irrigation, as it is a deep-rooted crop capable of drawing moisture from many feet of saturated soil. The greater fertility of the basin sediment is an advantage that probably outweighs the necessity of harrowing the deposit several times in years of heavy deposition in order to permit growth of the alfalfa. Therefore the benefits derived from greater accumulation of sediment in a silting basin would seem to make that type of project more desirable than any other that has been established in the coulee bottoms. On the other hand, a dam adequate to flood a given area is likely to cost much more than dikes that would serve the same purpose so far as moisture conservation is concerned. The large investment required for a dam may be endangered if spring floods fail to supply sufficient water in the early years of the project. A system of dikes can be developed over a period of years with a small labor force, and crop losses due to failure of water supply will not have so serious an effect on the financing of the farm.

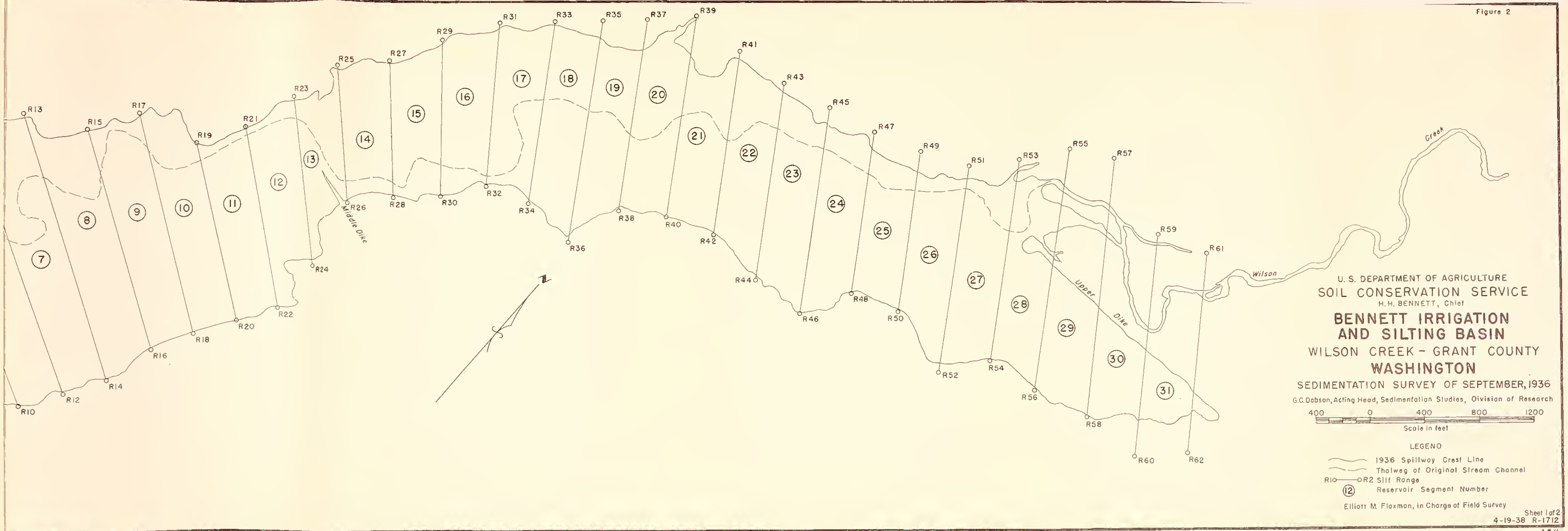
Figure 2
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, Chief
BENNETT IRRIGATION
AND SILTING BASIN
WILSON CREEK - GRANT COUNTY
WASHINGTON
SEDIMENTATION SURVEY OF SEPTEMBER, 1936
G.C. Dobson, Acting Head, Sedimentation Studies, Division of Research
400 0 400 800 1200
Scale in feet
LEGEND
1936 Spillway Crest Line
Thalweg of Original Stream Channel
R10 R2 Silt Range
12 Reservoir Segment Number
Elliott M. Flaxman, in Charge of Field Survey
Sheet 1 of 2
4-19-38 R-1712
Middle Dike
Upper Dike
Wilson
Creek

Figure 3

Nile Valley Dam
Gate
Middle Dike
Upper Dike
Gate
Wilson
Creek
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
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BENNETT IRRIGATION
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SEDIMENTATION SURVEY OF SEPTEMBER, 1936
G.C. Dobson, Acting Head, Sedimentation Studies, Division of Research
400 0 400 800 1200
Scale in feet
LEGEND
1936 Spillway Crest Line
Original Contours
1936 Contours
Silt Edge Below Crest - Shown Only When
When Widely Divergent From Crest Contour
Elliott M. Flaxmon, in Charge of Field Survey
Sheet 2 of 2
4-29-38 R-1712